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## Space Weather Technical Forecast

Issued on Tuesday, 16 May 2023 at 13:10 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales <https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales>

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**Space Weather Forecast Headline: Slight Chance of R1/R2 radio blackouts throughout, perhaps rising after midweek.**

### Analysis of Space Weather Activity over past 24 hours

**Solar Activity:** Solar activity has been Low over the last 24 hours, with X-ray activity measured at GOES16 confined to isolated low-end C-class flares, fronted by the tail end of the long-period peak C2.9 from the southeast limb, peaking prior to this reporting period.

There are currently six sunspot regions on the visible disc. AR3305 remains the largest and most complex group, and is the only one on the facing side that saw a significant growth trend, with its trailing group of spots increasing in number, size and spread. This has not as yet been capped by significant flare activity, despite a Zurich Dai classification.

Prior to the start of this reporting period, a filament was observed to leave the northwest disc around 15/1000UTC. This is undergoing assessment. Also of note on coronagraphs was a large Coronal Mass Ejection (CME) seen leaving the southeastern limb during the UTC afternoon of 15 May, first visible in Lasco C2 around 15/1500UTC. This may be linked to activity beyond the limb, and has been analysed as a miss behind and below the track of the Earth's orbit, despite a slightly front-sided solution from modelling. No confirmed Earth-directed CMEs were therefore in evidence.

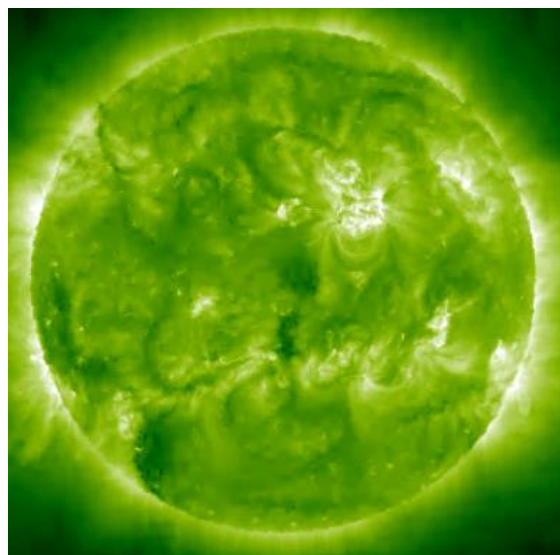


**Figure 0:** STEREO A EUVI 195 imagery from 16/1100UTC, showing around 10 degrees more of the upcoming eastern solar horizon when compared with an Earth-based line of sight. One, or possibly two bright flux regions on STEREO's horizon may hint at a tentative increase in activity is to be expected at Earth later this UTC week.

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**Solar Wind / Geomagnetic Activity:** The solar wind speed, as measured by DSCOVR at L1, was Slightly Elevated through the period, with an erratic trend through the upper 400s of km/s. The mechanism for this is not certain, with the positive phi periods (away from the Sun) perhaps linked to CH02/+, whose high solar latitude may go some way to explaining the faltering connection (with Earth), with drifting periods of negative phi and minor SSBCs as the period went on.

The solar wind density was level within its normal range of single figures ppcc. The IMF was also at background - at or below 7nT, while the north-south component varied between -5 and +6nT.

The net effect of the above solar wind measures was for Quiet to Unsettled geomagnetic activity, provisionally peaking at Kp '3o' in the 18-21UTC interval.

**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV), as measured at GOES16, remained at Background levels through the period.

High energy electron flux (greater than 2MeV), as measured at GOES16, was mostly within Normal Background levels. The 24-hour integrated fluence has been well below Active levels. At 16/0001UTC, 2.91e6 integrated pfu was recorded.

### **Four-Day Space Weather Forecast Summary**

**Solar Activity:** Solar activity carries an initial Slight Chance of becoming Moderate, perhaps increasing to a Chance after midweek UTC with the expected arrival of a CME-producing bright flux region over the southeastern limb, with no significant regions departing.

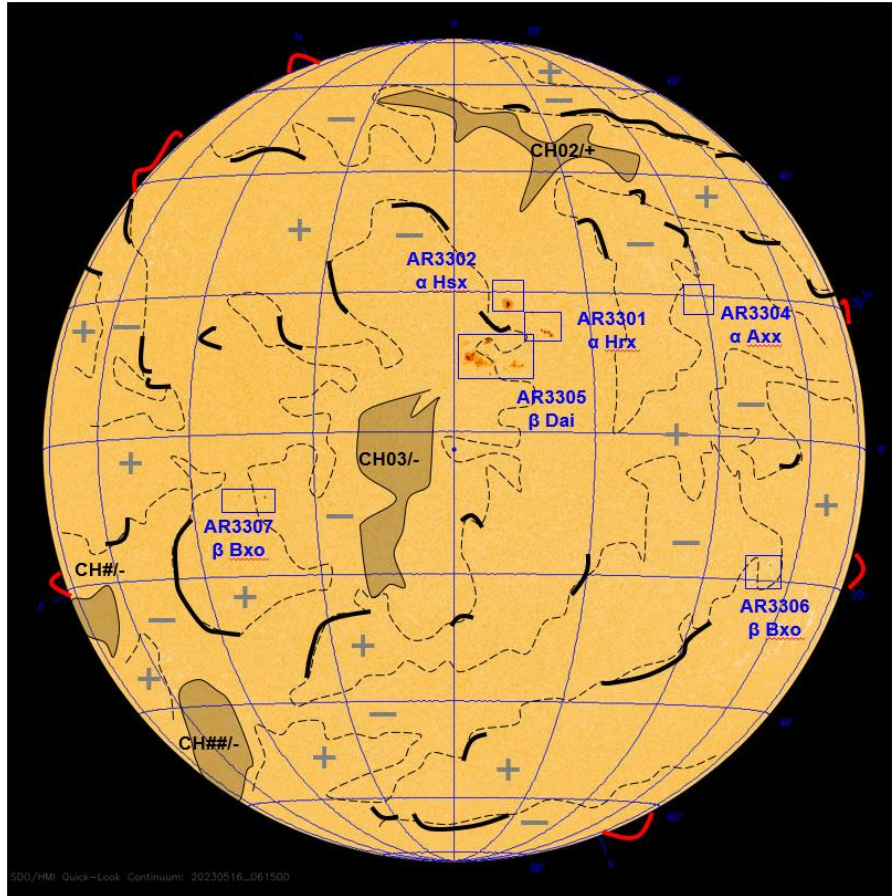
**Solar Wind / Geomagnetic Activity:** No CMEs now feature in the four-day forecast, although the 15/1000UTC northwestern quadrant filament is undergoing assessment.

Beyond the possible current marginal influence of CH02, the only coronal hole fast wind due in the four days is CH03, which is mooted for Friday 19 May. Although this is the peak risk of G1 for the period as a whole, it only offers a Slight Chance of G1, with Quiet conditions predominant until then.

**Energetic Particles / Solar Radiation:** The high energy (greater than 10 MeV) proton flux is most likely to persist at Background levels through the period.

High energy (greater than 2MeV) electron flux is expected to persist at mainly Normal Background levels. The associated 24-hour fluence is forecast to persist below the Active threshold.

**Figure 1. Solar Analysis Valid 16/0615UTC.**



**Key:** Filament \_\_\_\_, Prominence \_\_\_\_, Magnetic Field Line - - -, Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

## Geomagnetic Storms:

No CMEs currently feature in the four-day forecast, with the final of the three possible glancing blows (from 11, 12 and 13 May CMEs) now overdue and in all likelihood either missing Earth (as expected per the Enlil deterministic run), else being so late as to be non-impactful in terms of geomagnetism. The one caveat to this is that modelling results for the 15/1000UTC northwestern quadrant filament eruption are awaited.

Earth had been expected to be in a slow wind regime in the current period, however the solar wind speed is perhaps surprisingly high should this be the case in the upper 400s of km/s, and may better be explained by a tenuous connection to the high latitude CH02/+. This is obviously marginal for being able to affect Earth, which could help explain the drifting phi angle, although this is conjectural.

In the expected absence of CMEs, the sole driver of geomagnetic activity beyond the current dalliance with CH02 is expected to be CH03/-, which MOSWOC Enlil signals as arriving on or around Friday 19 May, with speeds of around 500km/s at peak. This is a persistent feature, however its last pass was completely swamped by the effects of the CME-driven G4 Severe Geomagnetic Storm, and as such its recent capabilities are untested. Having said this, because we are now nearing the solstice, the effects of this feature are nevertheless expected to be suppressed, with perhaps a token Slight Chance of a G1, in the peak risk for the period as a

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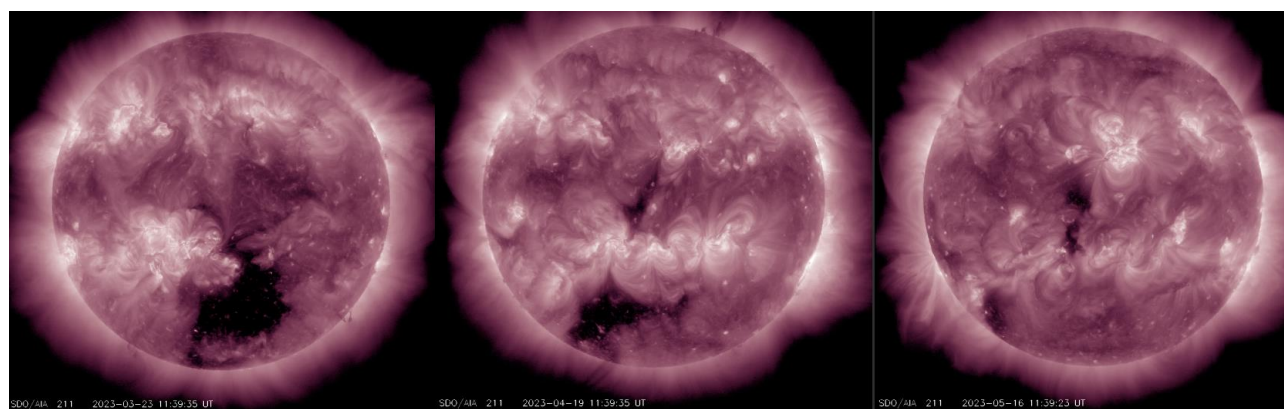
whole.

| Geo-Magnetic Storm       | Level    | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|----------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |          |                        | (%)               | (%)               | (%)               | (%)               |
| Minor or Moderate        | G1 to G2 | No                     | 1                 | 1                 | 1                 | 10                |
| Strong                   | G3       | No                     | 1                 | 1                 | 1                 | 1                 |
| Severe                   | G4       | No                     | 1                 | 1                 | 1                 | 1                 |
| Extreme                  | G5       | No                     | 1                 | 1                 | 1                 | 1                 |

## Geomagnetic Activity - Earthbound Coronal Mass Ejections

Nil.

Figure 2: Past three rotations of CH03/-, seen immediately east of centre disc in the more recent images (centre and rightmost) and little changed between these passes. While this would usually offer very good forecast value, the fact that the ensuing solar wind was masked by a CME and G4 on last rotation significantly lowers confidence, as its late March appearance was somewhat different (leftmost image).



## Radio Blackouts - X-Ray Flares:

The Penticton 10.7cm flux has been declining throughout the past week, falling from 180sfu on 09 May to reach 135 on 15 May, going some way to confirming that the Sun is undergoing something of a lull in activity, at least on the Earth-facing side.

There are currently six sunspot regions on the visible disc, the majority of which are decaying unipolar or else minor bipolar groups. The one main exception to this remains AR3305, which is the largest, most complex and only spot with any significant growth trend in the past 24 hours. Despite its recent growth, AR3305 has yet to produce significant activity, perhaps because for all its increase in size and number of spots, it remains fairly neatly a straightforward Mt Wilson Beta group.

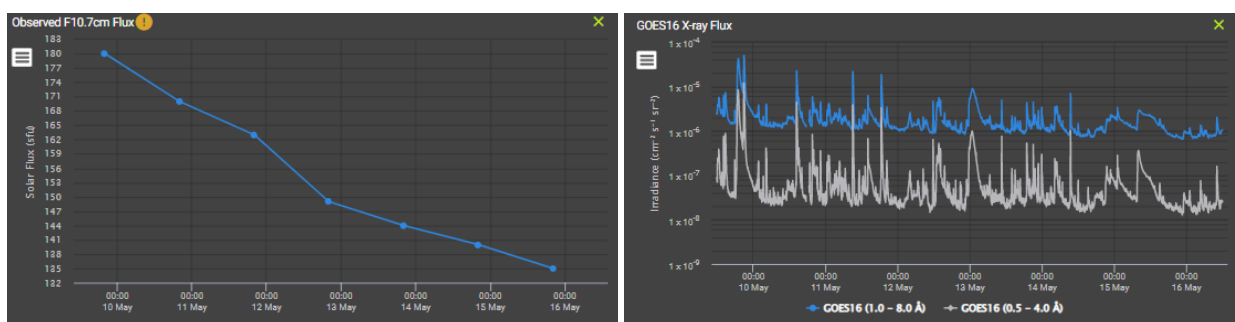
The balance of front-sided regions is a trade off between the departure of very minor AR3306 and AR3304 in the four days, weighed up against the likelihood of a larger, CME producing region narrowly over the southeast limb at present. With this in mind, the X-ray flare risk is

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tentatively upwards, albeit to an uncertain degree until any region here presents for analysis.

| X Ray Flares | Level            | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------|------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability  |                  |                        | (%)               | (%)               | (%)               | (%)               |
| Active       | R1-R2 M Class    | No                     | 20                | 30                | 30                | 30                |
| Very Active  | R3 to R5 X Class | No                     | 1                 | 1                 | 1                 | 1                 |

**Figure 3: Penticton 10.7cm flux and GOES16 X-ray flux, with both showing a recent decline in activity.**



## Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at Background levels throughout this 24-hour period.

Ex-3296 is now comfortably over the western solar horizon such that the risk from this spot group can now fade from consideration for the global S1 risks. By far the biggest new contributor to the daily risk is now AR3305 given its stature, however it has yet to produce significant flares, let alone proton enhancements. Despite this, it remains something to monitor and is the reason for the very gradual increase later in the period.

| Radiation Storms         | Level (cm <sup>-2</sup> sr <sup>-1</sup> s <sup>-1</sup> ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|------------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                            |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | ≥ S1                                                       | No                     | 2                 | 1                 | 2                 | 5                 |
| Very Active              | ≥ S3 *                                                     | No                     | 1                 | 1                 | 1                 | 1                 |

\* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = cm<sup>-2</sup>sr<sup>-1</sup>s<sup>-1</sup>)

## High Energy Electrons Event ( $\geq 2\text{MeV}$ ):

The high energy electron flux (greater than 2MeV) has remained largely at Normal Background levels over the past 24 hours, and this is likely to remain the case through the coming four days in the expected absence of any drivers for increasing counts.

The sole coronal hole on the disc, CH03/-, is mooted for a Friday 19 May arrival my MOSWOC Enlil. While this is a persistent feature, its last pass was dominated by a G4 Severe Geomagnetic Storm from a CME, and its predictive value is therefore very limited.

All considered, given the small stature of CH03 and its arrival perhaps not being until day four, any eventual effect on electron flux and fluence ought to fall outside the current four-day period, giving fluence levels comfortably below Active throughout.

| GEO Electron Environment | Level ( $\text{cm}^{-2} \text{sr}^{-1} \text{day}^{-1}$ ) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|--------------------------|-----------------------------------------------------------|------------------------|-------------------|-------------------|-------------------|-------------------|
| Probability (Exceedance) |                                                           |                        | (%)               | (%)               | (%)               | (%)               |
| Active                   | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^8$              | No                     | 1                 | 1                 | 5                 | 5                 |
| Very Active              | $\geq 2 \text{ MeV}$<br>$\geq 1 \times 10^9$              | No                     | 1                 | 1                 | 1                 | 1                 |